

**Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, DC 20554**

|   |   |                      |
|---|---|----------------------|
| In the Matter of                        | ) |                      |
|   | ) |                      |
| Revision of Part 15 of the Commission's | ) | ET Docket No. 98-153 |
| Rules Regarding Ultra-Wideband          | ) |                      |
| Transmission Systems                    | ) |                      |

**SUPPLEMENTAL COMMENTS OF  
THE BOEING COMPANY**

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## SUMMARY

The reports on which the Commission seeks public comment support Boeing's position that ultra-wide band ("UWB") devices should not be authorized on an unlicensed basis under Part 15 of the Commission's rules. The reports illustrate that there is still insufficient knowledge (based on real test data) to warrant Commission action at this time. They also show that the potential for interference from UWB devices depends greatly on the specific characteristics of the UWB waveform and that UWB devices are capable of causing significant interference to other spectrum users. As a result, the test data from these reports demonstrate that the power limitations of Part 15 alone are inadequate to ensure that UWB devices do not interfere with GPS.

Instead, if UWB devices are authorized, the Commission should set appropriate limits for such equipment and authorize them solely pursuant to a conditional licensing structure. Further study (and potentially a further NPRM) will be necessary in order to determine the precise details of the conditions of the licensing structure that will be necessary to adequately protect existing spectrum users – especially critical safety services such as GPS – from interference. The protection of existing safety services, such as GPS, from interference is without a doubt an absolute prerequisite to even considering the operation of UWB devices. If sufficient safeguards and conditions cannot be established to ensure protection of GPS and other existing spectrum users – particularly those providing critical safety services – from interference, then the Commission should not authorize the operation of UWB devices in restricted frequency bands.

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**SUPPLEMENTAL COMMENTS OF  
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The Boeing Company (“Boeing”) hereby provides supplemental comments in response to the public notice issued by the Commission in the above-captioned proceeding regarding three reports that have recently been submitted to the Commission on the interference potential of ultra-wideband (“UWB”) transmission systems to radiocommunications equipment operating with the global positioning system (“GPS”).<sup>1</sup>

The reports – conducted by the National Telecommunications and Information Administration,<sup>2</sup> the Department of Transportation/Stanford University,<sup>3</sup> and the John

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<sup>1</sup> Public Notice, *Comments Requested on Reports Addressing Potential Interference from Ultra-Wideband Transmission Systems*, DA 01-753, ET Docket No. 98-153 (Mar. 26, 2001) (“Public Notice”).

<sup>2</sup> U.S. Department of Commerce, National Telecommunications and Information Administration, *Assessment of Compatibility Between Ultrawideband (UWB) Systems and Global Positioning System (GPS) Receivers*, NTIA Special Publication 01-45 (Feb. 2001) (“NTIA Report”).

<sup>3</sup> Stanford University, *Potential Interference to GPS from UWB Transmitters: Phase II Test Results* (Mar. 16, 2001) (“DOT/Stanford Report”).

Hopkins University/Applied Physics Laboratory<sup>4</sup> – support Boeing’s position that UWB devices should not be authorized on an unlicensed basis under Part 15 of the Commission’s rules. Instead, if UWB devices are authorized, the Commission should set appropriate limits for such equipment and authorize them solely pursuant to a conditional licensing structure. Further study (and potentially a further NPRM) will be necessary in order to determine the precise details of the conditions of the licensing structure that will be necessary to protect existing spectrum users – particularly those providing critical safety services, such as GPS – from interference.<sup>5</sup> If sufficient safeguards and conditions cannot be established to protect GPS and other existing spectrum users from interference from UWB devices, then the Commission should not authorize the operation of UWB devices in restricted frequency bands.

## **I. INTRODUCTION**

As the Commission correctly – and repeatedly – acknowledges in its Notice of Proposed Rulemaking (“NPRM”) in this proceeding,<sup>6</sup> it is vitally important to ensure that

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<sup>4</sup> John Hopkins University/Applied Physics Laboratory, *Final Report: UWB-GPS Compatibility Analysis Project* (Mar. 8, 2001) (“JHU/APL Report”).

<sup>5</sup> Besides GPS, the potential for interference from UWB should be considered for other sensitive spectrum uses. In the aviation industry alone, such uses include – but are not limited to – Radio Altimeters, aircraft DME (Distance Measuring Equipment) systems, SATCOM (Satellite Communications), MLS (Microwave Landing System), ILS (Instrument Landing System), VOR (VHF Omnidirectional Range), ADF (Automatic Direction Finder), HF (High Frequency) and VHF (Very High Frequency) communications systems, TCAS (Traffic Alert and Collision Avoidance System), Mode S (Mode Select), ASR (Airport Surveillance Radar), and weather radar.

<sup>6</sup> See *Revision of Part 15 of the Commission’s Rules Regarding Ultra-Wideband Transmission Systems*, FCC 00-163, Notice of Proposed Rule Making, ET Docket No. 98-153 (May 11, 2000) (“NPRM”).

critical safety systems, such as GPS, are protected from harmful interference.<sup>7</sup> The Commission's commitment to the protection of GPS is well founded. Around the globe, GPS has become an essential and irreplaceable component of military and commercial aviation, and has become the backbone of virtually every application that requires precise time and location determination capabilities.

GPS is critical to Department of Defense operations and U.S. national security because of its heavy use in vehicle and aircraft navigation, missile guidance systems, communications, and rescue and recovery operations. Outside of the military, the Commission has recognized the expanded use of GPS for all sorts of applications, such as commercial and civil aviation, vehicle navigation, surveying, hiking, and geologic measurements.<sup>8</sup> The Commission has also noted the important role that GPS systems can play in wireless communications, such as GPS-based enhanced 911 ("E-911") services.<sup>9</sup> Thus, the Commission is absolutely right in concluding that "any harmful interference to GPS could have a serious detrimental impact on public safety, business, and consumers."<sup>10</sup>

Boeing unequivocally shares this commitment to the protection and furtherance of GPS technology. For nearly three decades, Boeing has played a leading role in the development of GPS. Boeing designed and built the first- and second-generation of GPS

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<sup>7</sup> *See id.* at ¶¶ 24, 29, and 39.

<sup>8</sup> *See id.* at ¶ 28.

<sup>9</sup> *See id.* ("We note also that GPS may be used by commercial mobile radio E-911 services to enable police and fire departments to quickly locate individuals in times of emergency.").

<sup>10</sup> *See id.*

Block I and II satellites and continues to take a leading role in the modernization and development of the next generation GPS Block IIF and Block III satellites. In addition, Boeing Delta rockets have launched every GPS satellite into orbit since 1989, and the U.S. Air Force has selected Boeing as the single prime contractor for GPS ground segment operations.

As the world's largest manufacturer of commercial and military aircraft, Boeing is also acutely aware of the critical role that GPS plays in existing and future Communications, Navigation and Surveillance ("CNS") and Air Traffic Management ("ATM") systems. The Commission has acknowledged this important role and observes that GPS is "increasingly relied upon for air navigation and safety, and is a cornerstone for improving the efficiency of the air traffic system."<sup>11</sup> Boeing anticipates that satellite-based CNS/ATM systems utilizing GPS technology will enable greater flexibility and capacity for the presently overtaxed air traffic control system, and is in the process of developing such space-based systems.<sup>12</sup> These future systems, however, rely on GPS as the cornerstone of their operations. Should new technologies, such as UWB, cause harmful interference to GPS, it would have a deleterious effect on the development of

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<sup>11</sup> *See id.*

<sup>12</sup> To this end, Boeing has an application pending before the Commission to launch and operate a medium Earth orbit ("MEO") non-geostationary ("NGSO") satellite system operating in the 2 GHz frequency band, which will be used to provide Aeronautical Mobile Satellite (Route) Service ("AMS(R)S") to the global aviation industry. *See The Boeing Company, Application for Authority to Launch and Operate a Non-Geosynchronous Medium Earth Orbit Satellite System in the 2 GHz Band Mobile-Satellite Service and in the Aeronautical Radionavigation-Satellite Service*, File Nos. 179-SAT-P/LA-97(16), 90-SAT-AMEND-98, SAT-LOA-19970926-00149 & SAT-AMD-19980318-00021. Boeing intends to file separate comments in this proceeding and in the 2 GHz proceeding regarding the potential impact of UWB on mobile-satellite services.

such future navigational systems, as well as the continuing viability of existing services that rely on GPS infrastructure.

**II. REPORTS ON POTENTIAL UWB INTERFERENCE SUPPORT  
BOEING'S POSITION THAT UWB DEVICES SHOULD NOT BE  
AUTHORIZED ON AN UNLICENSED BASIS PURSUANT TO PART 15  
OF THE COMMISSION'S RULES.**

As stated in previous comments in this proceeding,<sup>13</sup> Boeing opposes the authorization of any UWB systems (regardless of their power or pulse repetition frequency (“PRF”)) as unlicensed, low power devices under Part 15 of the Commission’s rules.<sup>14</sup> Simply put, Part 15 is wholly inadequate to protect existing spectrum users, such as GPS, from the potential harmful interference of UWB devices. The potential impact of ubiquitously deployed UWB systems – especially when considered in the aggregate and when operated in an unsupervised fashion – is too significant to permit authorization under a Part 15 regulatory regime that fails to provide the Commission with sufficient means to control the number and operation of UWB devices.

The reports submitted in this proceeding support Boeing’s position and illustrate that there is still insufficient knowledge (based on real test data) to warrant Commission action at this time. The reports also show that the potential for interference from UWB devices depends greatly on the specific characteristics of the UWB waveform and that UWB devices are capable of causing significant interference to other spectrum users. As a result, the test data from these reports demonstrate that the power limitations of Part 15 alone are inadequate to ensure that UWB devices do not interfere with GPS.

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<sup>13</sup> See *Comments of The Boeing Company*, ET Docket No. 98-153 (Sept. 12, 2000) (“Boeing Comments”).

<sup>14</sup> See *id.* at 13.



For example, the report conducted by the NTIA indicates that interference from UWB devices into GPS receivers is heavily dependent on a number of variables, such as the type of UWB signal structure, the environment in which the device is used, the power level that is employed, the potential for UWB signal aggregation, and the type of victim GPS receiver. The report shows that the combination of these variables results in differing levels of interference into GPS receivers.<sup>15</sup> Although some of these variables (such as power level) may be able to be controlled under Part 15 requirements, other variables (such as whether the UWB device is used outdoors or indoors or the architecture of the specific victim GPS receiver) are not suitable for control under Part 15.

Despite the fact that the NTIA Report includes testing for a variety of different UWB signals and a variety of GPS receivers (although the report fails to include military GPS receivers),<sup>16</sup> the set of test signals remains limited and the report itself warns against drawing general conclusions from the data.<sup>17</sup> Although the UWB signal permutations are intended to be representative of potential UWB applications, they do not cover the entire range of possible variations in the UWB signal design. This incomplete knowledge of the effects of some possible UWB signal designs – coupled with the lack of any rules in

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<sup>15</sup> See NTIA Report at x-xii, tbls. 1-4.

<sup>16</sup> See *id.* at v n.4.

<sup>17</sup> See *id.* at vi (“The data collected from these measurements are applicable only to the UWB signal permutations that were considered in this assessment. *No attempt should be made to extrapolate this data beyond these particular UWB parameters.*”) (emphasis added).

Part 15 to limit signal designs – could result in significant interference into GPS receivers above “white noise” levels.

Similarly, the DOT sponsored report conducted by Stanford University categorically shows that some UWB signal structures could result in interference to GPS that is many times worse than interference due to white noise. For example, the DOT/Stanford Report concludes that under certain conditions, high PRF UWB signals can be “significantly more damaging” than white noise.<sup>18</sup> Although the report notes that “under the best circumstances” high PRF UWB signals can appear as broadband noise, the report recognizes that this is only a best-case observation and that an actual UWB waveform can be more damaging than white noise if the UWB codes and modulation indices “are not chosen carefully.”<sup>19</sup>

Even if UWB waveforms could be designed and controlled such that the interference effect on GPS is minimized, this possibility does not validate the unlicensed operation of such devices under Part 15. Spectrum management must be designed to protect the victim systems from interference from the worst-case design allowed by the rules. Current Part 15 requirements, however, do not limit the UWB signal design other than by a specification of power in a one megahertz bandwidth. It must also be noted that the DOT/Stanford Report specifically states that its examination is limited to determining

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<sup>18</sup> See *DOT/Stanford Report* at 2 (“If [a high PRF] signal includes discrete spectral lines and these lines fall within the GPS band, then UWB can be significantly more damaging than broadband noise.”).

<sup>19</sup> *Id.* (“If the UWB dithering codes or modulation indices are not chosen carefully, and some spectral-line content remains, then the UWB waveform is more damaging than white noise.”).

the interference impact of a single UWB device and does not address the impact of aggregate interference from multiple UWB emitters on GPS.<sup>20</sup>

Even the JHU/APL Report, commissioned by a UWB proponent, concludes that the interference capabilities of UWB devices can vary widely depending on the characteristics of the UWB signal.<sup>21</sup> Although the JHU/APL Report notes that it is possible to design a UWB waveform so that the spectrum is essentially white noise-like (even in the aggregate),<sup>22</sup> there is little information provided in the report regarding how this is accomplished and exactly what the spectral characteristics of a system must be before this simple additive noise assumption is valid. More importantly, it must be noted that the current Part 15 rules include nothing that would limit the choice of UWB signal designs to those that are white noise-like. This is important, given that the JHU/APL Report acknowledges that certain UWB coding schemes can produce non-white noise-like signals that can negatively impact GPS performance.<sup>23</sup> Indeed, the report notes that for UWB devices with average powers that are compliant with current Part 15 regulations, the performance of GPS receivers exhibit severe degradation when in close

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<sup>20</sup> See *id.* at 3 (“[T]he results are limited to determining the interference impact of a *single* UWB transmitter relative to broadband noise. It was recognized that the impact of *multiple* UWB emitters must be determined as part of the overall UWB interference analysis effort.”) (emphasis in the original).

<sup>21</sup> See JHU/APL Report at ES-1 (“UWB time coding or modulation implementation determines the nature of the resulting UWB signal. This nature in turn determines the impact on a particular GPS receiver implementation and its performance. *The choice of time coding parameters can produce significant differences in the amount and type of performance effect experienced by GPS receivers.*”) (emphasis added).

<sup>22</sup> See *id.*

<sup>23</sup> *Id.* (“There exist coding schemes that can produce non-white noise-like UWB signals that may have greater impact on GPS performance than those effects shown herein.”).

proximity to UWB devices, even to the point of causing a loss of signal lock on all satellites.<sup>24</sup> Although the JHU/APL Report observes that GPS receiver performance converges to normal levels at certain separation from UWB devices, the minimum separation at which performance degradation becomes acceptable depends on a variety of factors.<sup>25</sup> Part 15 simply does not regulate these factors in any manner that would exclude the possibility of GPS performance degradation.

Finally, all the reports discussed above only examine potential UWB interference into GPS and do not examine UWB's impact on other spectrum users. There are numerous other additional frequencies and spectrum users that could be negatively impacted by the ubiquitous and uncontrolled deployment of UWB devices. As stated in previous comments, the Commission should be cautious and refrain from accepting the notion that GPS is the most vulnerable spectrum use implicated in this proceeding and assuming that if it can be shown that UWB does not interfere with GPS, then all other systems will likely not suffer from interference.<sup>26</sup> Such a notion certainly cannot be inferred from any of the reports examined above in this proceeding.

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<sup>24</sup> *See id.* (noting that “the performance of GPS receivers exhibits severe degradation when the separation between the GPS receiver and UWB devices is less than about 3 meters.”).

<sup>25</sup> *See id.* at ES-2 (observing that “The minimum separation at which degradations are acceptable depends on individual user scenarios including performance thresholds, GPS receiver and UWB device(s).”).

<sup>26</sup> *See* Boeing Comments at 7.

### **III. THE COMMISSION SHOULD INSTEAD SET APPROPRIATE LIMITS FOR SUCH EQUIPMENT AND AUTHORIZE THEM SOLELY PURSUANT TO A CONDITIONAL LICENSING STRUCTURE**

Although Boeing is fully committed to the protection of GPS and other existing spectrum users, it is also very interested in the potential beneficial applications of UWB that may not be possible using conventional transmission/modulation techniques.<sup>27</sup> Boeing's sole concern is that the practical applications of UWB technologies can be authorized only to the extent that they do not result in interference to existing spectrum uses, particularly those providing critical safety services such as GPS. As shown above, the record in this proceeding demonstrates that Part 15 is inadequate to provide such protection.

Instead, if the Commission does authorize the use of UWB devices (even if limited to low power/low PRF devices), it should only do so on a secondary basis through a conditional licensing structure. This conditional licensing could take the form of a "blanket" license that would permit a single entity (typically the manufacturer or distributor of the devices) to control the operation of multiple, technically identical UWB devices under a single license. The license should be restricted by setting an upper limit on the quantity of authorized devices and must contain important conditions on the deployment and operations of these devices that are necessary to protect GPS and existing spectrum users, particularly those providing safety services, from harmful interference.

Although further study is required before precise license conditions can be formulated, such conditions should include, among other things, limiting distribution to

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<sup>27</sup> See *id.* at 2.

public safety agencies, designing the equipment so that it can operate only when pointed to the ground, and defining specific areas of operation or areas where devices cannot be operated (for example, within a certain distance from an airport). Potential conditions should also place minimal record-keeping responsibilities on licensees to maintain records of all users, user contacts, and intended areas of operation so that interference can be quickly identified and shut down. Furthermore, the Commission must authorize UWB devices only on a secondary basis to all licensed services, especially GPS and other aviation and safety services.

The use of a conditional licensing structure would aid primary spectrum users and the Commission to identify operators of low power/low PRF UWB devices and to work with them to correct any unanticipated interference concerns in a manner that is unavailable under Part 15. Without a conditional licensing structure, the Commission may lack the resources necessary to control adequately the potential unintended harmful effects of ubiquitous UWB deployment. Therefore, a final rule should not be issued that permits authorization of any UWB devices under Part 15. Instead, if the Commission does determine that it is feasible to authorize the use of UWB technology, then a new conditional licensing structure should be developed only after a careful review of additional testing and studies (and potentially the issuing of a further NPRM) in order to determine the license conditions necessary to adequately protect GPS and other existing spectrum users.

It cannot be stressed enough, however, that the ultimate goal of the Commission in this proceeding must be to protect critical safety services from interference. The protection of existing safety services such as GPS from interference is without a doubt an

absolute prerequisite to even considering the operation of UWB devices. If sufficient safeguards and conditions cannot be established to ensure the protection of GPS and other existing spectrum users from interference, then the Commission should not authorize the operation of UWB devices in restricted frequency bands. Such an absolute prohibition is consistent with the Commission's own determination that the authorization of UWB operations is only possible to the extent that such operations do not cause interference to critical safety systems, particularly GPS.<sup>28</sup>

#### **IV. CONCLUSION**

Although Boeing supports the exploitation of new technologies and the development of technologies that may allow more efficient use of the spectrum, it is greatly concerned that such new technology does not come at the expense of existing spectrum users, especially GPS and other critical safety systems. Authorization of ubiquitous UWB devices under Part 15 is simply inadequate to protect existing spectrum users. The reports submitted in response to the Public Notice do not provide a sufficient basis for the Commission to authorize any UWB devices (regardless of their power or PRF) pursuant to Part 15. Instead, if such devices can be authorized at all, the Commission can do so only by adopting a conditional licensing structure for UWB devices. Although further study, and possibly a further NPRM, is necessary in order to determine the precise details of license conditions, a conditional licensing structure

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<sup>28</sup> See *NPRM* at ¶ 7 (“[W]e recognize that any new rule provisions for UWB devices must ensure that radio services are protected against interference.”); see also *id.* at ¶ 24 (“First, we believe that it is vitally important that critical safety systems operating in the restricted frequency bands, including GPS operations, are protected against interference.”).

should provide necessary means of control on the deployment and operation of UWB devices in order to protect existing spectrum users, particularly GPS. If sufficient safeguards and conditions cannot be established to ensure the protection of GPS and other existing spectrum users from interference, then the Commission should not authorize the operation of UWB devices in restricted frequency bands.

Respectfully submitted,

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